

Application No. 10/721,108
Prelim Amdt. Dated 04/30/04

In the Specification:

Please amend the following paragraphs:

[0010] The present invention provides a diesel engine comprising a fuel injector which injects fuel into a cylinder, and fuel injection control means for controlling the amount of fuel that is injected from this fuel injector and the timing of this fuel injection, wherein the abovementioned fuel injection control means [[perform]] performs an early-stage injection of a relatively small amount of fuel divided into a plurality of injections in the compression stroke, and [[perform]] performs a main injection of a relatively large amount of fuel after a specified period has elapsed following the completion of the early-stage injection, the abovementioned early-stage injection is performed using a fuel injection amount and fuel injection timing which are such that the generation of heat caused by fuel of the early-stage injection occurs in the vicinity of compression top dead center, and the abovementioned main injection is performed using a fuel injection amount and fuel injection timing which are such that the generation of heat caused by fuel of the main injection occurs after the generation of heat caused by fuel of the early-stage injection has been completed.

[0012] Preferably, furthermore, the abovementioned fuel injection control means [[perform]] performs the abovementioned main injection after compression top dead center.

[0013] Furthermore, the present invention provides a fuel injection method for a diesel engine, wherein the early-stage injection of a relative small amount of fuel is performed with this injection divided into a plurality of injections during the compression stroke of the engine, the main injection of a relatively large amount of fuel is performed [[is]] after a specified period has elapsed following the completion of the early-stage injection, the abovementioned early-stage injection is performed using a fuel injection amount and fuel injection timing which are such that the generation of heat caused by fuel of the abovementioned early-stage injection occurs in the vicinity of compression top dead center, and the abovementioned main injection is performed using a fuel injection amount

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and fuel injection timing which are such that the generation of heat caused by fuel of the main injection occurs after the generation of heat caused by fuel of the early-stage injection has been completed.

[0023] Fig. 8 shows the results of a test investigating the conditions of heat generation inside the cylinder caused by fuel injection, and shows an example in which [[a]] two early-stage injections and a main injection were performed; and

[0024] Fig. 9 shows the results of a test investigating the conditions of heat generation inside the cylinder caused by fuel injection, and shows an example in which [[a]] three early-stage [[injection]] injections and a main injection were performed.

[0029] An EGR (Exhaust Gas Recirculation) device 19 is also installed in this engine. The EGR device 19 comprises an EGR pipe 20 that connects the intake pipe 12 and the exhaust pipe 13, an EGR valve 21 which is used to regulate the amount of EGR, and an EGR cooler 22 which cools the EGR gas on the upstream side of the EGR valve 21. An intake throttle valve 23 which is used to appropriately throttle the intake air on the upstream side of the connecting part with the EGR pipe 20 is installed in the intake pipe 12.

[0039] At the timing of the early-stage injection A shown in Figs. 2a and 2b, the piston is still rising, and is lower than compression top dead center; furthermore, the interior of the cylinder is at a low pressure, and the air density is low. When a conventional early-stage injection A such as that shown in Fig. 2a is performed in such a state, since the injection rate is high, the penetration of the fuel jet mist is excessively strong in relative terms, thus creating problems such as the adhesion of the fuel jet mist to the inside walls of the cylinder, accompanying exhaust of HC and CO and the like. In the present embodiment shown in Fig. [[2 b]] 2b, on the other hand, the injection rates of the respective injections performed in the early-stage injection A can be kept at low values. As a result, the abovementioned problems can be eliminated. Furthermore, the object of this early-stage injection is pre-mixing of the fuel; here, performing the early-stage

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injection a plurality of times with a small amount of fuel being injected each time as in the present embodiment is more advantageous for dispersion of the fuel into the cylinder and uniform pre-mixing of the fuel in a short time than a system in which a large amount of early-stage injection is performed at one time as in conventional methods.

[0049] However, if the main injection is performed while this heat generation is occurring, the fuel jet mist created by the main injection suddenly enters the hot flame; as a result, there is insufficient mixing of the fuel and air, so that smoke is aggravated. In order to avoid this aggravation of smoke, it would appear that it is desirable for the generation of heat caused by the fuel of the main injection to occur (as indicated by F in Figs. 8 and 9) after the generation of heat in the vicinity of TDC caused by the early-stage injection indicated by E in Figs. 8 and 9 has been completed. The heat generation caused by the main injection indicated by F in Figs. 8 and 9 shows a higher heat generation peak value than the heat generation caused by the main injection indicated by G in the same figures, and this is because it appears that the fuel injected in the main injection participates in combustion without forming smoke. As a result, furthermore, there is a prospect of improvement of the output power and fuel consumption.